

Incidence and Outcome of Acute on Chronic Kidney Disease Requiring Dialysis in a Single Rural Tertiary Center

Sirayut Waramit^{1,2*}

¹ Department of Medicine, Sakon Nakhon Hospital, Sakon Nakhon, Thailand

² Faculty of Medicine, Kasetsart University, Bangkok, Thailand

*Corresponding Author: Sirayut Waramit, MD., Department of Medicine, Sakon Nakhon Hospital, Sakon Nakhon, 47000, Thailand. Tel: +66-0817390747, Email: sirayusm@outlook.com

Received January 1, 2024; Accepted February 22, 2024; Online Published March 15, 2024

Abstract

Background: Acute kidney injury appears to be both the cause and the result of developing chronic kidney disease. "Acute on chronic kidney disease" refers to acute kidney injury that develops in the presence of pre-existing chronic kidney disease.

Objectives: This study aimed to gain a better understanding of the disease's incidence and outcomes in a rural area.

Methods: A retrospective analysis was conducted to identify individuals with acute or chronic kidney disease who had acute dialysis at Sakon Nakhon Hospital in Thailand between January 2021 and December 2022. The patient's demographics, clinical symptoms, laboratory values, and outcomes were documented.

Results: There were 82 patients with acute kidney injury requiring dialysis, of which 35 (42.7%) had acute on chronic kidney disease. The mean age was 61.6 ± 13.46 years, with 48.6% being male. Diabetes was the most frequent primary cause and comorbid condition (60%). The majority of indication for acute dialysis (57.1%) was volume overload. Sepsis (37.1%), and urinary tract obstruction (25.7%) were the leading causes of acute renal function decline. There was a significant difference in risk variables between non-survivors and survivors, including shock ($P < 0.00001$), mechanical ventilation use ($P = 0.0017$), and Intensive Care Unit (ICU) admission ($P = 0.0005$). Significant mortality-related risk factors identified by logistic regression analysis were shock [OR 159.00, 95%CI 6.86-3683.71; $P = 0.002$], mechanical ventilation usage [OR 30.79, 95%CI 1.59-597.71; $P = 0.024$], and ICU admission [OR 43.00, 95%CI 2.18-847.42; $P = 0.013$].

Conclusion: Acute on chronic kidney disease increased not just in-hospital mortality and morbidity, but also the risk of chronic kidney disease onset and progression.

Keywords: Chronic Kidney Disease, Dialysis, Risk Factor

1. Background

Acute Kidney Injury (AKI) is defined by a sudden and rapid decrease in Glomerular Filtration Rate (GFR), which is typically reversible. AKI is a common condition, with an estimated population frequency of 2,000-3,000 per million. A major US population study¹ found that the community-based incidences of non-dialysis-requiring AKI and dialysis-requiring AKI were 3840.1 and 240.4 per million individuals, respectively. When AKI occurs in conjunction with pre-existing chronic kidney disease, the term "Acute on Chronic Kidney Disease" (ACKD) is used. Epidemiological data on ACKD are limited because it has not been properly explored. The incidence of ACKD is lower as a population figure, estimated at 300 to 600 per million people.² The risk of ACKD is inversely proportional to the baseline renal function. Patients with the lowest GFR have a higher risk of developing ACKD. This observation is acceptable given that patients with CKD have a lower renal reserve.

There is compelling evidence that pre-existing CKD is a substantial risk factor for the development of AKI;

thus, ACKD accounts for a sizable proportion of AKI cases.³ Over the last decade, studies have shown that AKI is associated with an increased risk of developing End-Stage Renal Disease (ESRD), as well as an increase in long-term morbidity and mortality.⁴ There is an increasing recognition that AKI and CKD are intricately linked and likely promote each other.⁵⁻⁷ The severity of CKD, the stage of AKI, and the cumulative number of AKI events all contribute to the link between AKI and subsequent renal function loss.^{8,9} As almost half of the CKD patients who experienced AKI episodes later developed ESRD,^{10,11} patients in the early stages of CKD were routinely instructed how to avoid AKI events in order to block and delay disease progression. Despite these precautions, a small proportion of CKD patients required frequent admissions due to a precipitous reduction in renal function following AKI episodes, which exacerbated their CKD. It may be possible to delay the progression of these patients' diseases by identifying and treating the factors that cause acute declines in renal function.

2. Objectives

The objective of this study was to better understand the incidence and outcomes of AKI in patients with pre-existing CKD in a remote rural area of Thailand. As the number of AKI survivors grows, we must better understand other clinically relevant outcomes following AKI, identify those at highest risk for the most adverse sequelae, and devise measures to optimize their treatment.

3. Methods

Patients requiring acute dialysis at Sakon Nakhon Hospital, a rural tertiary center in Thailand, were identified between January 2021 and December 2022. The integrated medical record system of the hospital, which identified each patient with a blind number, served as the basis for a retrospective analysis. Cases of dialysis-requiring kidney disease were collected among hospitalized patients who had measures of serum creatinine prior to admission and who were not already on maintenance dialysis. AKI requiring dialysis was defined as peak inpatient serum creatinine greater than the last observed pre-admission out-patient serum creatinine by $\geq 50\%$ and receipt of dialysis during hospitalization. The diagnosis of ACKD was based on the kidney disease: Improving Global Outcomes (KDIGO) Consensus Conference.¹² The patients were discharged with the diagnosis codes of ACKD according to the International Classification of Disease, Tenth Revision, Clinical Modification, and were considered for inclusion in the study. Baseline GFR was estimated from serum creatinine determinations not associated with hospitalizations to better reflect baseline

kidney function. It was defined as the last outpatient GFR before admission. If a patient was hospitalized more than once for ACKD during the study period, only the data from the first admission was analyzed. The exclusion criteria included AKI without CKD or ESRD. All patients who had received a prior kidney transplant or were on maintenance dialysis. Subjects who had no records of serum creatinine values over a six-month period before admission or during hospitalization were not included in the study. While renal function recovery was defined as 1) Full recovery, serum creatinine concentrations fell to the baseline. 2) Partial recovery: serum creatinine remained above the baseline. 3) Failure to recover: dialysis dependent at 90 days. Data was collected on the patient's demographic characteristics, clinical manifestations, causes of acute deterioration, laboratory parameters, and outcomes. This study was approved by the Ethics Committee of Sakon Nakhon Hospital, Thailand. COE No. 053/2566. The study adhered to the principles of the Declaration of Helsinki, 2013.

3.1. Statistical Analysis

The continuous variables were presented as the mean \pm standard deviation. Kolmogorov–Smirnov test was used to check the normality of the data. Categorical variables were presented as percentages or proportions. For the univariate analysis, we compared two groups using the Student's t-test when normally distributed and the Mann-Whitney test when not. The Pearson χ^2 test was applied for the analysis of nominal variables. A binomial logistic regression analysis was performed to assess the impact of ACKD on hospital mortality. The adjusted odds ratio and

Table 1. Characteristics and Presentations of Patients

Characteristic	Number of cases (%)
Age (years)	61.6 \pm 13.46
Gender	
Male	17 (48.6)
Female	18 (51.4)
Etiology of chronic kidney disease	
Diabetes	21 (60)
Urinary tract stone	7 (20)
Hypertension	3 (8.6)
Glomerular disease	3 (8.6)
Autoimmune disease	1 (2.9)
Co-morbidity	
Diabetes	21 (60)
Hypertension	21 (60)
Cardiovascular disease	7 (20)
Cerebrovascular disease	1 (2.9)
Malignancy	1 (2.9)
Symptom at presentation	
Volume overload dyspnea	20 (57.1)
Oliguria/Anuria	8 (22.8)
Encephalopathy	4 (11.4)
Lethargy	2 (5.7)
Nausea/Vomiting	1 (2.9)
Cause of acute deterioration of renal function	
Sepsis	13 (37.1)
Urinary tract obstruction	9 (25.7)
Decreased renal perfusion	7 (20.0)
Volume depletion	5 (14.3)
Drugs	1 (2.9)

the 95% confidence interval for each notable risk factor in the model were derived. Data was analyzed using Statistics Kingdom® (Version.2017, Australia). All tests were two-tailed, and $P < 0.05$ was considered statistically significant.

4. Results

Out of 891 dialysis patients, 82 had AKI and required dialysis, with 47 (57.3%) in the group without CKD and 35 (42.7%) in the group with CKD. The average age of the sample was 61.6 ± 13.46 years, with 48.6% males. Diabetes was the leading cause of CKD (60%) and comorbid illness (60%) among patients. The most common clinical manifestation for acute hemodialysis was volume overload (57.1%). Sepsis (37.1%), urinary tract blockage (25.7%), and reduced renal perfusion (20.0%) were the

leading causes of acute renal function decline (Table 1).

Patients had mean laboratory levels of blood urea nitrogen 86.3 ± 36.13 mg/dl, serum creatinine 7.8 ± 4.11 mg/dl, serum albumin 2.9 ± 0.55 g/dl, hemoglobin 9.1 ± 2.29 g/dl, serum Na^+ 134.6 ± 7.13 mEq/l, serum K^+ 4.6 ± 1.04 mEq/L, and serum HCO_3 15.9 ± 6.02 mmol/L (Table 2).

The average period of admission was 15.9 ± 13.35 days. In patients with severe symptoms, 40% were admitted to the Intensive Care Unit (ICU), 45.7% required mechanical ventilation, 37.1% suffered from sepsis, and 25.7% experienced shock. There were three categories of clinical outcomes for ACKD that required dialysis: complete recovery (57.1%), incomplete recovery (14.3%), and non-recovery (5.7%). Seven patients died, one of whom was discharged contrary to medical advice. The overall death rate among patients was 20% (Table 3).

Table 2. Laboratory Parameters of Patients

Laboratory parameters	Mean presentation values
Serum creatinine (mg/dl)	7.8 ± 4.11
Blood urea level (mg/dl)	86.3 ± 36.13
Serum Na^+ (mEq/L)	134.6 ± 7.13
Serum K^+ (mEq/L)	4.6 ± 1.04
HCO_3 level (mmol/L)	15.9 ± 6.02
Hemoglobin level (g/dl)	9.1 ± 2.29
White blood count (/mm ³)	$12,172 \pm 5,985$
Platelet count (/mm ³)	$210,771 \pm 116,419$
Serum calcium (mg/dl)	8.4 ± 0.76
Serum phosphorus (mg/dl)	6.2 ± 3.14
Serum uric acid (mg/dl)	6.8 ± 1.24
Serum albumin (g/dl)	2.9 ± 0.55

Table 3. Hospitalization Features and Outcomes of Patients

Characteristic	Number of cases (%)
Duration in hospital (days)	15.9 ± 13.35
ICU admission	14 (40.0)
Mechanical ventilation	16 (45.7)
Sepsis	13 (37.1)
Shock	9 (25.7)
Recovery	
Complete	20 (57.1)
Incomplete	5 (14.3)
Failure to recover	2 (5.7)
Death	7 (20.0)
Against advice	1 (2.9)

Identification of risk factors which impact clinical outcomes, patients were separated into two groups: survivors and non-survivors. Significant risk factors

included shock ($P < 0.00001$), mechanical ventilation use ($P = 0.0017$), and ICU admission ($P = 0.0005$). These findings were consistent with the mortality predictions

Table 4. Characteristics Stratified by Survivors and Non-Survivors

Factor	All (%)	Survivors (%)	Non-survivors (%)	P-value
Male gender	17 (48.6)	12 (34.3)	5 (14.3)	0.23
Old age (>60 years)	18 (51.4)	12 (34.3)	6 (17.1)	0.09
Co-morbidity				
Diabetes	21 (60)	16 (45.7)	5 (14.3)	0.68
Hypertension	21 (60)	18 (51.4)	3 (8.6)	0.40
Cardiovascular disease	7 (20)	5 (14.3)	2 (5.7)	0.61
Severity				
Sepsis	13 (37.1)	9 (25.7)	4 (11.4)	0.38
Shock	9 (25.7)	2 (5.7)	7 (20)	$< 0.00001^*$
Mechanical ventilation	16 (45.7)	9 (25.7)	7 (20)	0.0017^*
ICU admission	14 (40)	7 (20)	7 (20)	0.0005^*
Laboratory				
Albumin <3 g/dl	20 (57.1)	16 (45.7)	4 (11.4)	1.00
Hemoglobin <8 g/dl	11 (31.4)	10 (28.6)	1 (2.9)	0.39
$\text{K}^+ > 5.5$ mEq/L	5 (14.3)	4 (11.4)	1 (2.9)	1.00
$\text{HCO}_3 < 15$ mmol/L	15 (42.9)	10 (28.6)	5 (14.3)	0.11

*Statistical significance ($P < 0.05$)

Table 5. Risk Factors of Patient Mortality

Factor	Odds ratio	95% Confidential Interval	P-value
Male gender	3.33	0.54-20.22	0.191
Old age (>60 years)	8.00	0.85-75.56	0.069
Co-morbidity			
Diabetes	1.87	0.31-11.37	0.494
Hypertension	0.42	0.08 - 2.25	0.309
Cardiovascular disease	2.24	0.34-14.92	0.404
Severity			
Sepsis	3.26	0.60-17.59	0.169
Shock	159.00	6.86-3683.71	0.002*
Mechanical ventilation	30.79	1.59-597.71	0.024*
ICU admission	43.00	2.18-847.42	0.013*
Laboratory			
Albumin < 3 g/dl	1.58	0.31-8.15	0.582
Hemoglobin < 8 g/dl	0.30	0.03-2.86	0.295
Serum K ⁺ > 5.5 mEq/L	1.00	0.09-10.66	1.000
Serum HCO ₃ < 15 mmol/L	4.50	0.73-27.58	0.104

*Statistical significance ($P < 0.05$)

made using logistic regression analysis. The odds ratio and 95% confidence interval for three risk factors were significant in shock [OR 159.00, CI 6.86-3683.71; $P = 0.002$], mechanical ventilation usage [OR 30.79, CI 1.59-597.71; $P = 0.024$], and ICU admission [OR 43.00, CI 2.18-847.42; $P = 0.013$] (Tables 4 and 5).

5. Discussion

According to the findings of this study, individuals with AKI requiring acute dialysis had a significantly higher proportion of CKD (42.7%). Previous research found that the incidence of ACKD varied between 10% and more than 30%, depending on the study population.^{13,14} In one of the few community-based investigations, ACKD was found in nearly 13% of individuals presenting with AKI.¹⁵ In contrast, the incidence was higher in hospital-based studies, with ACKD accounting for 30% of AKIs in the United States, 33% in Australia, and 35.5% in China.¹⁶ The patients' ages were extremely high, and they had a number of associated diseases, especially diabetes and hypertension. The incidence was comparable to an earlier study.¹⁷ Accordingly, patients with low perfusion frequently see a decline in GFR. Patients with CKD frequently have reduced autoregulation and lack the necessary compensatory mechanisms to offset a decline in renal perfusion. Diabetes and hypertension are two common causes of CKD that impair the autoregulatory response. They are the leading causes of chronic kidney disease, which results in end-stage renal failure worldwide. Glomerular damage, renal arteriosclerosis, and atherosclerosis are all important factors in diabetic and hypertensive patients, which leads to kidney damage development. Diabetes is a very strong risk factor for AKI, and AKI is linked to rapid progression of renal impairment in diabetic patients. AKI's long-term implications include the development of end-stage renal disease, increased cardiovascular events, poor quality of life, and a high morbidity and mortality rate. Patients with CKD are more vulnerable to hemodynamic fluctuation and possible ischemia due to a reduction in autoregulatory systems. In individuals with pre-existing

CKD, any of the precipitating events, particularly volume depletion, may result in AKI in addition to chronic renal function decline. Sepsis (37.1%) was the most common cause of acute impairment of renal function in this study, which was similar to the 12% described by Peerapornratana et al.¹⁸ Compared to AKI, ACKD is linked to more severe renal impairment, and a larger proportion of patients in this group require acute dialysis during hospitalization. The majority of patients (69%) had severe symptoms, such as shock, sepsis, and acute respiratory failure. They were then placed on mechanical ventilators and treated in an ICU. In severe outcomes of ACKD patients, dialysis is required and the in-hospital mortality rate may surpass 30 to 50%.¹⁹ However, the mortality rate in this study was lower (20%). Following up with patients for 90 days during the recovery period revealed that total recovery was 57.1%, which was close to the 51% reported by Hsu et al.²⁰ The proportion of patients that progressed to ESRD was 20%, while Raji et al. reported 27.5%.²¹ Patients who experience an episode of ACKD are more likely to advance to CKD, develop ESRD, and die. Patients with the most severe form of ACKD have an inpatient mortality rate of 34-54%.²² Of those who survive hospitalization, between 27% and 77% develop ESRD, with individuals with the lowest baseline GFR being at the greatest risk.²³ Patients who experienced an abrupt decline in renal function may recover after the reason of the acute event is identified. As a result, any unexpected reduction in renal function in patients with known CKD necessitated prompt screening, diagnosis, and appropriate therapy to avoid an accelerated and potentially irreversible decline in renal function.²⁴ There is apparently a link between AKI, partial or delayed recovery, and CKD. The patient may have CKD or be presenting for the first time, having previously been undiagnosed with it. CKD predisposes to bouts of AKI, hence optimal CKD management is critical to lowering the risk of AKI.²⁵

As patients with ACKD often have several comorbidities, it is difficult to evaluate the attributable mortality of ACKD to the other conditions that contributed

to ACKD. In this study, factors associated with death in ACKD patients included mechanical ventilator use, ICU hospitalization, and shock. This link might possibly represent the severity of illness in a subset of these individuals who had other organ system failures that cause death. This finding was consistent with previous investigations by Peres et al.,²⁶ Kaul et al.,²⁷ and Uchino et al.²⁸ The association between age and gender and in-hospital mortality was not found to be statistically significant, in contrast to findings reported by Oluseyi et al.,²⁹ Poukkanen et al.,³⁰ and Kohli et al.,³¹ which revealed that older age was related with increased mortality. Hamzić-Mehmedbašić et al.³² found a link between female gender and higher mortality. However, older CKD patients typically have many co-morbidities and a weakened immune system, increase their risk of severe CKD worsening and rapid progression to ESRD and death. Comorbidities, such as hypertension, diabetes, and cardiovascular disease, did not have a statistically significant effect on in-hospital mortality in this study. Diabetes and an increased number of comorbidities were reported to be related to mortality in ACKD patients in previous research by Sezer et al.³³ and Samimaghani et al.³⁴ In contrast to Ostermann and Chang³⁵ and Peres et al.,²⁶ severe metabolic acidosis was not associated with in-hospital mortality in this study. Hyperkalemia and leukocytosis were associated with in-hospital mortality in a prior study by Dela Cruz et al.,³⁶ but not in our study. Furthermore, unlike Saxena et al.,³⁷ the presence of albuminemia did not have a significant effect on relative risk. The risk of AKI increases with worsening baseline renal function, with a 3-fold greater risk of AKI when creatinine clearance was <60 ml/min compared to normal creatinine clearance, and a risk of approximately 4.5 times in individuals with creatinine clearance \leq 40 ml/min.^{38,39} Patients with CKD, particularly those in later stages (GFR less than 30 ml/min/1.73 m²), frequently do not show linear disease progression, which could be due to superimposed bouts of AKI or other causes.⁴⁰ As a result, preventing AKI is an important element of managing CKD.

In developing countries, poor AKI outcomes are attributed to a lack of healthcare staff, diagnostic equipment, and hospital resources. Rural locations may lack the necessary infrastructure for AKI treatment, hence a structured referral system is essential for optimal AKI management. Treatment options for more severe AKI cases may be limited due to a lack of skilled personnel and dialysis equipment. Inadequate kidney function monitoring is an even bigger issue in developing countries, reducing patients' chances of recovery and progression to CKD.

6. Conclusion

ACKD increased not just in-hospital mortality and

morbidity, but also the risk of CKD onset and progression, as well as significant adverse cardiovascular events. AKI should be regarded a medical emergency. If there was an obvious cause, this should be addressed. However, a lack of patient care resources in rural hospitals remains a significant obstacle to care for these patients.

Research Highlights

What Is Already Known?

Acute Kidney Injury (AKI) is a common disorder. Patients with Chronic Kidney Disease (CKD), as evidenced by a low GFR or presence of proteinuria, are at higher risk for developing AKI, a condition known as acute on chronic renal failure (ACKD). CKD is a strong risk factor for cardiovascular events, and patients with CKD are at particular mortality risk if they develop ACKD.

What Does This Study Add?

If the underlying cause of the acute component of ACKD can be ascertained, it should be treated promptly. Hemodynamics and blood pressure should be optimized. If the sequelae of ACKD cannot be managed medically, prompt consideration of acute dialysis should be done.

Conflict of Interest Disclosures

The author declares no conflicts of interest.

References

1. Makris K, Spanou L. Acute kidney injury: definition, pathophysiology and clinical phenotypes. *Clin Biochem Rev.* 2016;37(2):85-98.
2. Coca SG, Singanamala S, Parikh CR. Chronic kidney disease after acute kidney injury: a systematic review and meta-analysis. *Kidney Int.* 2012;81(5):442-8. doi:10.1038/ki.2011.379
3. Hsu RK, Hsu CY. The role of acute kidney injury in chronic kidney disease. *Semin Nephrol.* 2016;36(4):283-92. doi:10.1016/j.semnephrol.2016.05.005
4. Rewa O, Bagshaw SM. Acute kidney injury—epidemiology, outcomes and economics. *Nat Rev Nephrol.* 2014;10(4):193-207. doi:10.1038/nrneph.2013.282
5. Zhou Q, Zhao C, Xie D, Xu D, Bin J, Chen P, et al. Acute and acute-on-chronic kidney injury of patients with decompensated heart failure: impact on outcomes. *BMC Nephrol.* 2012;13:51. doi:10.1186/1471-2369-13-51
6. Geri G, Stengel B, Jacquelinet C, Aegerter P, Massy ZA, Vieillard-Baron A. Prediction of chronic kidney disease after acute kidney injury in ICU patients: study protocol for the PREDICT multicenter prospective observational study. *Ann Intensive Care.* 2018;8:77. doi:10.1186/s13613-018-0421-7
7. He L, Wei Q, Liu J, Yi M, Liu Y, Liu H, et al. AKI on CKD: heightened injury, suppressed repair, and the underlying mechanisms. *Kidney Int.* 2017;92(5):1071-83. doi:10.1016/j.kint.2017.06.030
8. Hsu CY, Ordonez JD, Chertow GM, Fan D, McCulloch CE, Go AS. The risk of acute renal failure in patients with chronic kidney disease. *Kidney Int.* 2008;74(1):101-7. doi:10.1038/ki.2008.107
9. Dear JW, Yuen PS. Setting the stage for acute-on-chronic kidney injury. *Kidney Int.* 2008;74(1):7-9. doi:10.1038/ki.2008.126
10. Bamgboye EL. End-stage renal disease in sub-Saharan Africa. *Ethn Dis.* 2006;16:5-9.

11. Ayodele OE, Okunola OO, Afolabi MO, Oluyombo R, Gbadegesin BA, Oyeleye AE. Prevalence of hypertension, diabetes and chronic kidney disease in participants of the 2009 World Kidney Day screening exercise in Southwest Nigeria. *Hong Kong J Nephrol.* 2011;13(2):55-63. doi:10.1016/j.hkjn.2011.09.004
12. Lameire NH, Levin A, Kellum JA, Cheung M, Jadoul M, Winkelmayer WC, et al. Harmonizing acute and chronic kidney disease definition and classification: report of a Kidney Disease: Improving Global Outcomes (KDIGO) Consensus Conference. *Kidney Int.* 2021;100(3):516-26. doi:10.1016/j.kint.2021.06.028
13. Lafrance JP, Djurdjev O, Levin A. Incidence and outcomes of acute kidney injury in a referred chronic kidney disease cohort. *Nephrol Dial Transplant.* 2010;25(7):2203-9. doi:10.1093/ndt/gfq011
14. Ohlmeier C, Schuchhardt J, Bauer C, Brinker M, Kong SX, Scott C, et al. Risk of chronic kidney disease in patients with acute kidney injury following a major surgery: a US claims database analysis. *Clin Kidney J.* 2023;16(12):2461-71. doi:10.1093/ckj/sfad148
15. Picken M, Long J, Williamson GA, Polichnowski AJ. Progression of chronic kidney disease after acute kidney injury: role of self-perpetuating versus hemodynamic-induced fibrosis. *Hypertension.* 2016;68(4):921-8. doi:10.1161/HYPERTENSIONAHA.116.07749
16. Lo LJ, Go AS, Chertow GM, McCulloch CE, Fan D, Ordoez JD, et al. Dialysis-requiring acute renal failure increases the risk of progressive chronic kidney disease. *Kidney Int.* 2009;76(8):893-9. doi:10.1038/ki.2009.289
17. Kovcsy CP, Naseer A, Sumida K, Molnar MZ, Potukuchi PK, Thomas F, Streja E, Heung M, Abbott KC, Saran R, Kalantar-Zadeh K. Abrupt decline in kidney function precipitating initiation of chronic renal replacement therapy. *Kid Int Rep.* 2018;3(3):602-9. doi:10.1016/j.ekir.2017.12.007
18. Peerapornratana S, Manrique-Caballero CL, Gymez H, Kellum JA. Acute kidney injury from sepsis: current concepts, epidemiology, pathophysiology, prevention and treatment. *Kidney Int.* 2019;96(5):1083-99. doi:10.1016/j.kint.2019.05.026
19. Hamroun A, Frimat L, Laville M, Metzger M, Combe C, Fouque D, et al. New insights into acute-on-chronic kidney disease in nephrology patients: the CKD-REIN study. *Nephrol Dial Transplant.* 2022;37(9):1700-9. doi:10.1093/ndt/gfab249
20. Hsu CY, Chertow GM, McCulloch CE, Fan D, Ordon JD, Go AS. Nonrecovery of kidney function and death after acute on chronic renal failure. *Clin J Am Soc Nephrol.* 2009;4(5):891-8. doi:10.2215/CJN.05571008
21. Raji YR, Ajayi SO, Bello TO, Jinadu OY, Salako BL, Arije A, et al. Precipitants of acute exacerbation of chronic kidney disease: A single centre experience. *Trop J of Nephrol.* 2016;11(2):81-8.
22. Heung M, Steffick DE, Zivin K, Gillespie BW, Banerjee T, Hsu CY, et al. Acute kidney injury recovery pattern and subsequent risk of CKD: an analysis of veterans health administration data. *Am J Kidney Dis.* 2016;67(5):742-52. doi:10.1053/j.ajkd.2015.10.019
23. Lameire NH, Levin A, Kellum JA, Cheung M, Jadoul M, Winkelmayer WC, et al. Harmonizing acute and chronic kidney disease definition and classification: report of a Kidney Disease: Improving Global Outcomes (KDIGO) Consensus Conference. *Kidney Int.* 2021;100(3):516-26. doi:10.1016/j.kint.2021.06.028
24. Hatakeyama Y, Horino T, Kataoka H, Matsumoto T, Ode K, Shimamura Y, et al. Incidence of acute kidney injury among patients with chronic kidney disease: a single-center retrospective database analysis. *Clin Exp Nephrol.* 2017;21:43-8. doi:10.1007/s10157-0161243-2
25. Levey AS. Defining AKD: the spectrum of AKI, AKD, and CKD. *Nephron.* 2022;146(3):302-5. doi:10.1159/000516647
26. Peres LA, Wandeur V, Matsuo T. Predictors of acute kidney injury and mortality in an Intensive Care Unit. *J Bras Nefrol.* 2015;37:38-46. doi:10.5935/0101-2800.20150007
27. Kaul A, Sharma RK, Tripathi R, Suresh KJ, Bhatt S, Prasad N. Spectrum of community-acquired acute kidney injury in India: a retrospective study. *Saudi J Kidney Dis Transpl.* 2012;23(3):619-28.
28. Uchino S, Kellum JA, Bellomo R, Doig GS, Morimatsu H, Morgera S, et al. Acute renal failure in critically ill patients: a multinational, multicenter study. *JAMA.* 2005;294(7):813-8. doi:10.1001/jama.294.7.813
29. Oluseyi A, Ayodeji A, Ayodeji F. Aetiologies and short-term outcomes of acute kidney injury in a tertiary centre in Southwest Nigeria. *Ethiop J Health Sci.* 2016;26(1):37-44. doi:10.4314/ejhs.v26i1.8
30. Poukkanen M, Vaara ST, Reinikainen M, Selander T, Nisula S, Karlsson S, et al. Predicting one-year mortality of critically ill patients with early acute kidney injury: data from the prospective multicenter FINNAKI study. *Crit Care.* 2015;19:125. doi:10.1186/s13054-015-0848-2
31. Kohli HS, Bhat A, Jairam A, Aravindan AN, Sud K, Jha V, et al. Predictors of mortality in acute renal failure in a developing country: a prospective study. *Ren Fail.* 2007;29(4):463-9. doi:10.1080/08860220701260651
32. Hamzić-Mehmedbašić A, Rašić S, Balavac M, Rebić D, Delić-Šarac M, Durak-Nalbantić A. Prognostic indicators of adverse renal outcome and death in acute kidney injury hospital survivors. *J Renal Inj Prev.* 2016;5(2):61-8. doi:10.15171/jrip.2016.14
33. Sezer MT, Demir M, Gungor G, Senol A. Predictors of mortality in patients with acute renal failure. *Acta Medica.* 2006;49(3):183.
34. Samimagham HR, Kheirkhah S, Haghighi A, Najmi Z. Acute kidney injury in intensive care unit: incidence, risk factors and mortality rate. *Saudi J Kidney Dis Transpl.* 2011;22(3):464-70.
35. Ostermann M, Chang RW. Acute kidney injury in the intensive care unit according to RIFLE. *Crit Care Med.* 2007;35(8):1837-43. doi:10.1097/01.CCM.0000277041.13090.0A
36. Cruz CM, Pineda L, Rogelio G, Alano F. Clinical profile and factors affecting mortality in acute renal failure. *Ren Fail.* 1992;14(2):161-8. doi:10.3109/08860229209039126
37. Saxena A, Meshram SV. Predictors of mortality in acute kidney injury patients admitted to medicine intensive care unit in a rural tertiary care hospital. *Indian J Crit Care Med.* 2018;22(4):231-7. doi:10.4103/ijccm.IJCCM_462_17
38. Kline J, Rachoin JS. Acute kidney injury and chronic kidney disease: it's a two-way street. *Ren Fail.* 2013;35(4):452-5. doi:10.3109/0886022X.2013.766572
39. Chawla LS, Eggers PW, Star RA, Kimmel PL. Acute kidney injury and chronic kidney disease as interconnected syndromes. *N Engl J Med.* 2014;371(1):58-66. doi:10.1056/NEJMra1214243
40. Gautam SC, Brooks CH, Balogun RA, Xin W, Ma JZ, Abdel-Rahman EM. Predictors and outcomes of post-hospitalization dialysis dependent acute kidney injury. *Nephron.* 2015;131(3):185-90. doi:10.1159/000441607